VOL. 2, ISSUE 2-3 SPRING/SUMMER 2024

ISSN: 2835-8171

ICUAS MAGAZINE

State-of-the-art and recent developments in unmanned aviation

Editorial Board

EDITOR-IN-CHIEF
Kimon P. Valavanis
kvalavanis@icuas.com

ELECTRONIC SERVICES
Panos A. Valavanis
pvalavanis@icuas.com

ART, PRODUCTION & MEDIA
Nadia Danezou
danezou@icuas.com

Editors

Luis Mejias Alvarez
luis.mejias@qut.edu.au

Elizabeth J. Kaiser
ejjkxck@gmail.com

Hao Liu
liuhao13@buaa.edu.cn

Benjamyn I. Scott
b.i.scott@law.leidenuniv.nl

Alejandro Suarez
asuarezfm@us.es

Contact us:

4550 E. Cherry Creek S. Drive, Unit 305
Denver, CO 80246 - USA
Ph: (303) 862-6548 Cell: (303) 718-3097

Kimon P. Valavanis
Founder & President
kvalavanis@icuas.com

Nadia Danezou
Art, Production & Media
danezou@icuas.com

EDITORIAL

Dear colleagues and readers:

The Spring and Summer combined issue of the eMagazine is devoted to the aftermath of the very successful ICUAS 2024 that took place in Chania, Crete, in Greece, on June 4-7. After summarizing the conference's technical aspects, the results of a detailed survey are presented, along with relevant recommendations for the upcoming annual meetings. Our objective remains the same: make ICUAS the best small/medium size annual event in unmanned aviation. Note that the Conference Proceedings have appeared on IEEE Xplore, see https://ieeexplore.ieee.org/xpl/conhome/10556795/proceeding, DOI: 10.1109/ICUAS60882.2024. Alternatively, the proceedings may be downloaded from www.icuas.com. The issue includes two scientific articles with titles, respectively: «*Flying Robots Competition: Advancing the state-of-the-art in UAV systems through a ludic activity*», «*From Sky-High Dreams to Grounded Reality? Regulatory Considerations Behind Air-Taxis in Paris Olympics*».

ICUAS 2024 REPORT

ICUAS 2024 has been attended by participants spanning academia, industry, government agencies, the legal sector, policy makers, manufacturers, students, practitioners, and end-users.

In response to the Call for Papers, 313 contributed, invited session, and poster papers were submitted. The paper review process was extremely thorough and rigorous. All papers were checked for originality using the *iThenticate Document Viewer Guide*. Each paper had at least three (total) reviews, counting the reviews of the Program Chairs and the Associate Editors. The Technical Program included 160 contributed papers, 24 invited session papers, and 11 poster papers, for a total of 195 peer reviewed papers. The acceptance ratio

ICUAS Association, Inc. - All Rights Reserved

was about 62%, which is the lowest since the beginning of the Conference.

The Conference venues were the "Centre of Mediterranean Architecture (KAM)" and the "Mikis Theodorakis" Theatre Hall, two historical and iconic buildings from the 15th century, located in the Venetian harbor of the Old Town of Chania. The KAM building is also called the "Great Shipyard" (Megalo Arsenali).

Centre of Mediterranean Architecture - KAM

Mikis Theodorakis Theatre

ICUAS'24 OFFERED FIVE PRE-CONFERENCE WORKSHOPS/TUTORIALS THAT ADDRESSED CURRENT AND FUTURE TOPICS IN UNMANNED AIRCRAFT SYSTEMS

1. Aerial Workers for Infrastructure and Asset Maintenance: The Journey from "Lab" to "Real-World"
2. Navigating the Ethical Skies: Community Best Practices for Drones and UAVs
3. Modeling and Control of Multirotor UAVs: A Comprehensive Framework
4. International methodologies for conducting Beyond Visual Line of Sight (BVLOS) flight operations with Remotely Piloted Aircraft Systems (RPAS)
5. Heterogeneous Robotic System for Inspection and Intervention in GNSS-denied Environments

THE CONFERENCE INCLUDED FOUR PLENARY LECTURES

1. **Vision-Based Robotic Perception: Are We There Yet?**, Dr. Margarita Chli, Vision for Robotics Lab, ETH Zurich & University of Cyprus
2. **Biologically Inspired Drones,** Dr. Dario Floreano, Laboratory of Intelligent Systems, EPFL
3. **Aerospace City in Torino: Project and Strategy,** Dr. Fulvia Quagliotti President, Piemonte Aerospace Cluster
4. **Mapping Advanced Air Mobility to Mature Flight Operations,** Dr. Chester Dolph, Aeronautics Systems Engineering, NASA Langley Research Center

The Technical Program spanned three full days and it was composed of 32 Sessions, two Poster Paper Sessions, and the UAV Competition Session. The six finalist teams of the 2024 UAV Competition were:

- **AIRo Lab,** Zheng Tan and Wenyu Yang, The Hong Kong Polytechnic University, Hong Kong
- **ITUAV,** Onat Erdogmus and Levent Emre Nalici, Istanbul Technical University, Turkey
- **AVANT-UFMG,** Yan Figueiras Alves and Leonardo Reis Domingues Paes, Universidade Federal de Minas Gerais (UFMG), Brazil
- **UNIST ASL,** Taewook Park and Myeonggeun Gu, Ulsan National Institute of Science & Technology, Republic of Korea
- **UAS-DTU,** Kush Garg and Somin Aggarwal, Delhi Technological University, India
- **AVADER AGH,** Remigiusz Mietla, AGH, University of Krakow, Poland

ICUAS Association, Inc. - All Rights Reserved

THE CONFERENCE INCLUDED A VERY RICH SOCIAL AGENDA

A view of the entrance gate of the venue.

Committee members Nikos Tsourveloudis, Nadia Danezou, Kimon Valavanis, during a break.

Opening Ceremony

Honoring the ICUAS founder Kimon Valavanis. Nikos Tsourveloudis (left) Didier Theilliol (right).

Opening remarks by the General Chair, Nikos Tsourveloudis.

Dr Michael Zervakis, Rector TUC, opens the conference.

Dr. Margarita Chli, presents her Keynote lecture.

ICUAS Association, Inc. - All Rights Reserved

THE CONFERENCE INCLUDED A VERY RICH SOCIAL AGENDA

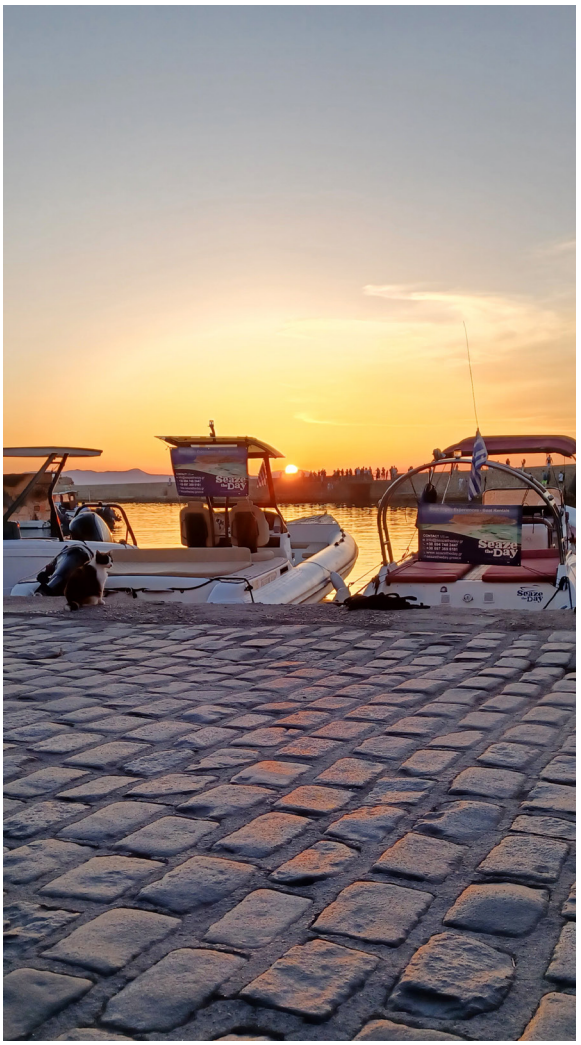
Conference participants enjoy coffee and lunch breaks.

ICUAS captain, Kimon Valavanis with the registration crew.

View from the conference venue.

ICUAS Association, Inc. - All Rights Reserved

THE CONFERENCE INCLUDED A VERY RICH SOCIAL AGENDA



Enjoying a Committee dinner.

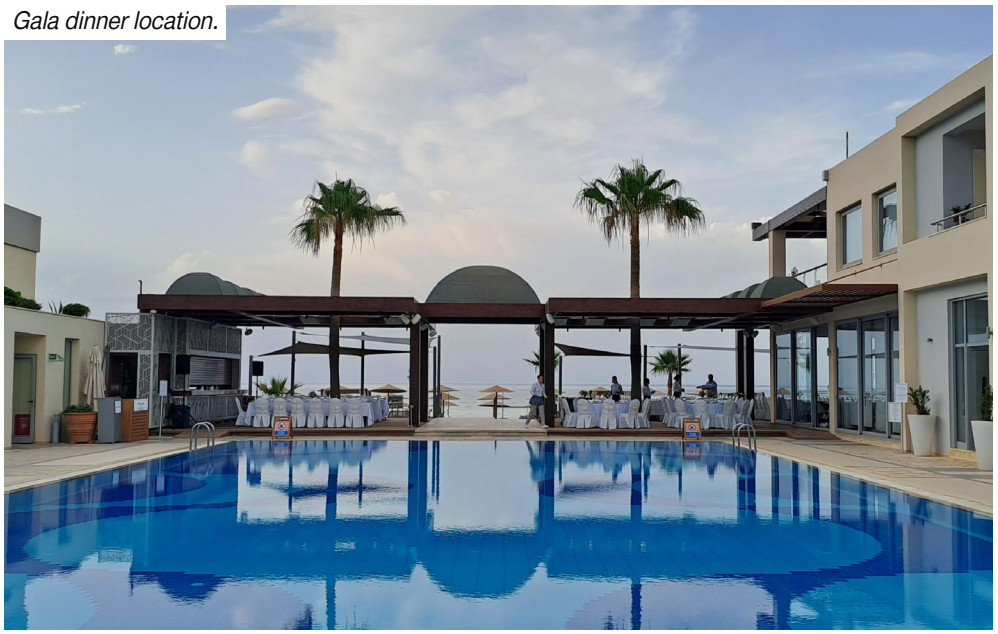
IEEE UAS Association, Inc. - All Rights Reserved

THE CONFERENCE INCLUDED A VERY RICH SOCIAL AGENDA

ICUAS 2024 has been in honor of Dr. Anibal Ollero. Nikos Tsourveloudis and Kimon Valavanis present an award to Dr. Ollero.

H. J. Kim, Giuseppe Loianno, Nikos Vitzilaios during the awards ceremony.

Gala dinner location.



Entertainment program.

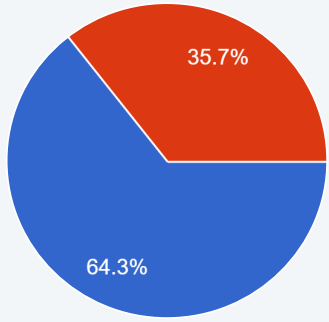
Following the Conference, a survey was sent to all participants with the aim to solicit feedback to improve future meetings. The results of the survey are shown next.

FEEDBACK SURVEY

- ONLINE SURVEY FROM JUNE 21 – JULY 7, 2024
- SENT TO ALL ICUAS 2024 REGISTERED ATTENDANTS
- 13 QUESTIONS IN TOTAL
- RECEIVED 70 RESPONSES

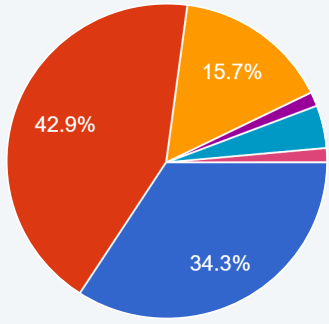
Is this the first time you attend the ICUAS conference?

70 responses



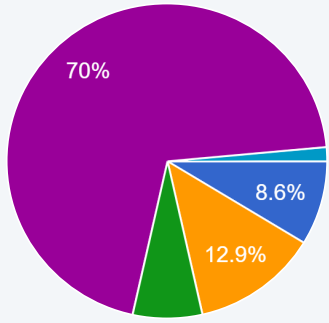
Job Role

70 responses



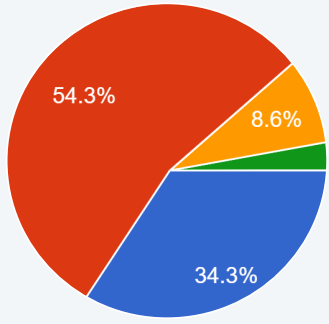
Affiliation Location

70 responses



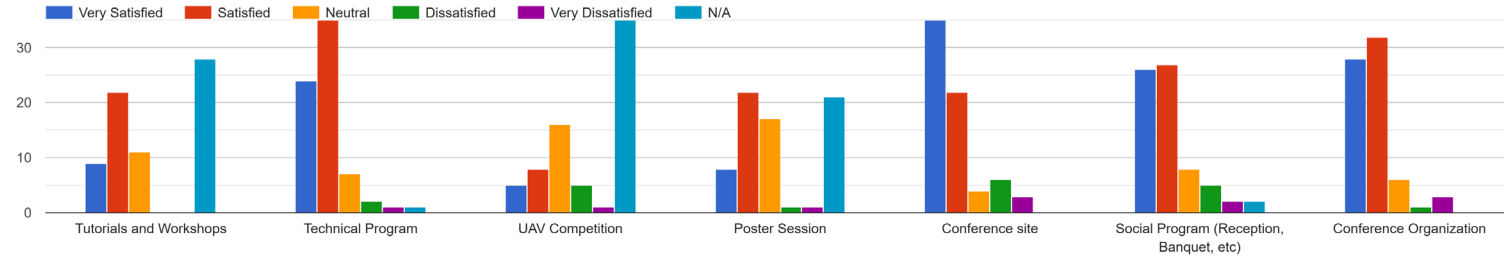
Please rate your ICUAS 2024 experience

70 responses

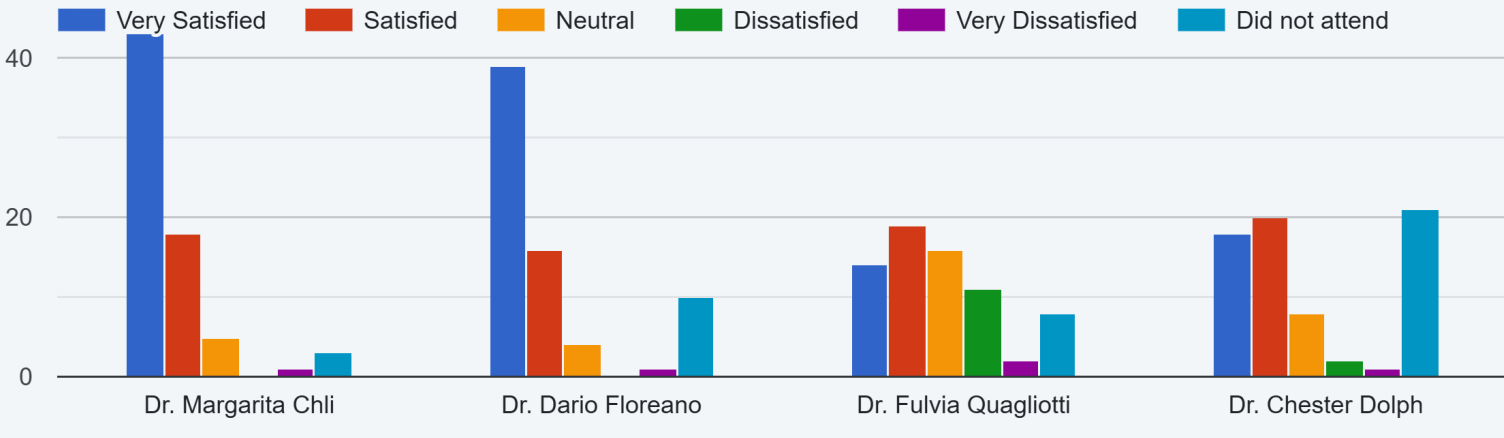


ICUAS Association, Inc. - All Rights Reserved

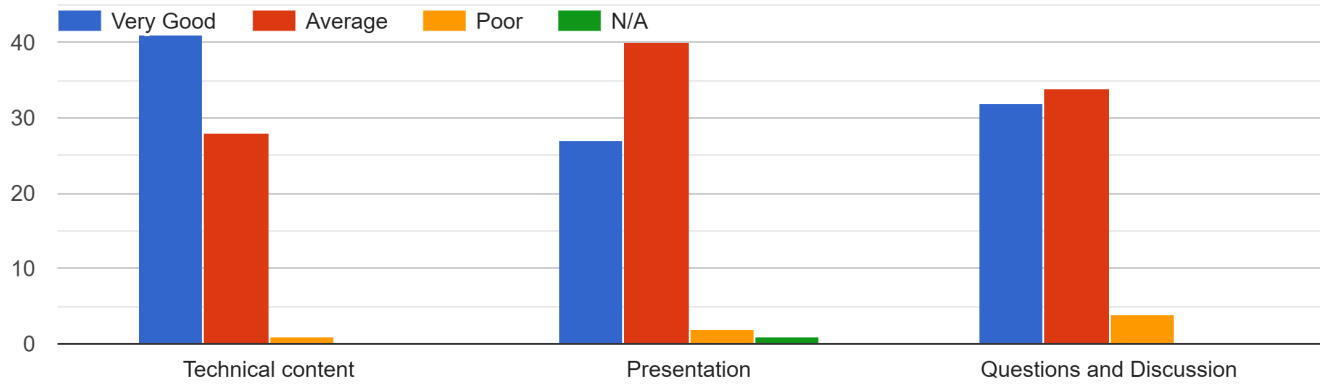
Please rate the quality of:



Please rate the quality of the keynote talks:

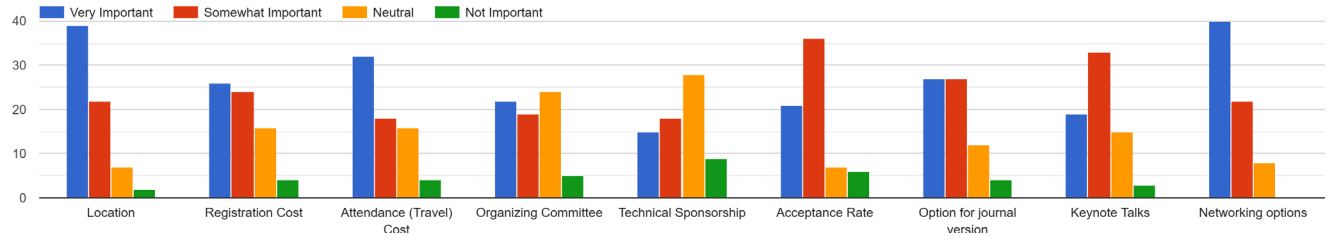


Please rate the quality of the papers:



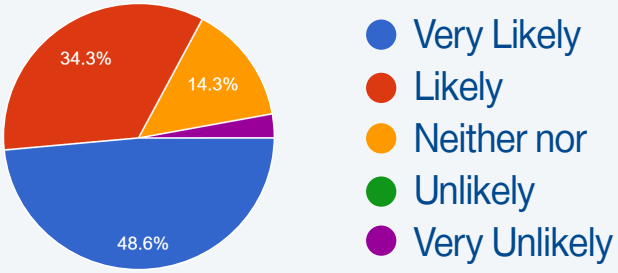
IEEE UAS Association, Inc. - All Rights Reserved

HOW IMPORTANT ARE THE FOLLOWING IN YOUR DECISION TO ATTENT ICUAS?



How likely are you to attend ICUAS 2025?

70 responses



ICUAS 2024 Survey - Conclusions

- Overall high satisfaction, successful event.
- Most people acknowledge the improvement in paper quality, however, there is still room for improvement.
- Very high satisfaction with the keynote talks.
- Overall high satisfaction with the venue and organization except for the coffee\lunch breaks that raised some concerns. Also, some concerns raised about the smaller presentation rooms.
- There were some concerns for splitting the event in different locations, ideally all events should be in the same location.
- It is desired to have a physical (on-site) UAV competition.
- Comments\suggestions for:
  - more networking options in future events
  - more industry involvement
  - wider geographical representation

LATEST NEWS IN UNMANNED AVIATION

1. For the latest news in unmanned aviation click on https://uasmagazine.com Check COMMERCIAL UAV NEWS to get access to the latest report on «Unleashing the Power of DRones Across Europe: Safety, Sustainability, and Beyond.

2. EU Drone Port has reached a significant milestone in drone technology. The startup has been officially recognised by the European Commission as a Notified Body for drone certification.

On the following pages you'll find the full press release.
For media support, you can see this link: https://drive.google.com/drive/folders/1kEzlLSofHkLJ7zLBH_abKQExowbJ1Y2y?usp=drive_link

ICUAS Association, Inc. - All Rights Reserved

FLYING ROBOTS COMPETITION: ADVANCING THE STATE-OF-THE-ART IN UAV SYSTEMS THROUGH A LUDIC ACTIVITY

AUGUSTO DE HOLANDA B. M. TAVARES, MEMBER, IEEE, SARAH P. MADRUGA, MEMBER, IEEE, TIAGO P. NASCIMENTO, SENIOR FELLOW, IEEE [1,2]

Abstract— Robotics competitions have stimulated scientific advances in the last decades, using competition to foment innovation. This paper describes a case of study and current rules of the Flying Robots Trial League, an initiative that started at the 2018 Brazilian Robotics Competition, where a set of teams composed of undergraduate students compete in a set of challenges with autonomous quadrotors. By carefully complying with the proposed tasks, the environment that was created enabled by 2023, the solutions for the competition challenges that resulted in published papers, converting a ludic activity into advancements into the state-of-the-art.

I. INTRODUCTION

Robotics competitions have a long history of shaping young talents in the STEM disciplines into future roboticists[4]. Due to the wide range of applications, several competitions have emerged in the last decades, ranging from robot soccer[1,5], signal processing[2], and factory-inspired scenarios[7]. In such competitions, teams from research and educational institutions have the opportunity to test theoretical and simulation-based knowledge in practical scenarios, with the added bonus of motivation derived from healthy competition against fellow roboticists. As Unmanned Aerial Vehicles (UAVs) achieve widespread use due to advancements in battery and propulsion technology along with a reduction in costs [6], it is only natural that competitions focusing on this class of aerial robots arise, aiming to provide the same benefits observed at competitions in more traditional robotic categories.

There are competitions for UAVs posing challenges in agriculture[13], search and rescue missions[9], navigation in extreme environments[7], and control engineering[3]. Quadrotors are usually the platform of choice due to their widespread availability, relatively low cost, and adaptability to different scenarios. Furthermore, due to the potential for catastrophic failures and the under-actuated nature of these class of vehicles, constructing a vehicle with reliable autonomous navigation for indoor and outdoor environments can be a challenge in of itself for participating teams, demanding a reasonable degree of expertise in electronics, parts acquisition and manufacturing, control engineering and programming.

One such competition for aerial robots is the Flying Robots Trial League (FRTL), established in 2018 as a part of the RoboCup Brazil competition. The main goal of the FRTL is to foster advancements in state-of-the-art of quadrotor robots with regard to new solutions for navigation, vision, and interaction problems through a series of challenges modeled after real-life scenarios. This article gives an overview of the competition rules, challenges, and results achieved so far, showing that, as in other areas of robotics, the use of ludic activities can lead to actual scientific contributions as students are encouraged by competition to innovate and deepen their understanding of scientific problems.

IEEE UAS Association, Inc. - All Rights Reserved

II. THE ROBOTS

The UAVs used by the teams must be quadrotors, a subset of the rotary-wing aerial vehicles class. For most of the stages, quadrotors with a maximum of 500mm between opposite rotors and a maximum weight of 10kg are allowed, such as the one shown in Fig. 1. In 2024, one of the competition stages has a human inside the competition arena interacting with the robot, so, in this case, the maximum size allowed for the quadrotors is 250mm between opposite rotors and a maximum weight allowance of 1kg, as seen in Fig. 2.

Figure 1
The x500 quadrotor used by the 2023 FRTL winning team Capybots.

Figure 2
Example of a x250 quadrotor for the 2024 FRTL.

Since the main objective of the FRTL is to promote advances in state-of-the-art technology, it is encouraged that all competing robots adhere to an open hardware standard. That is, a list of employed components and build guides should be available for each of the robots in the competition. In the case of 3D printed pieces, custom circuit boards, and other similar components, the base files should all be made available. The basic firmware used in the vehicles should also be public.

However, at this early stage in the competition's history, lowering the barrier of entry is the highest priority. Therefore, off-the-shelf quadrotors are still allowed as long as they adhere to the same standards as the open-hardware alternatives. Apart from size and weight restrictions, the quadrotors of all teams must be able to perform autonomous indoor flights since the competition is held in an arena located inside a convention center. A human pilot must be on stand-by with a controller as a safety precaution, but if the human takes control of the vehicle, the team will score no further points in a given attempt.

The requirement of autonomous indoor flights implies that all teams must solve the mapping and location problems in this class of operational environment to a minimal standard. Since GNSS signals are unreliable inside buildings, technologies such as LIDAR and RGB-D cameras must be used in conjunction with SLAM and visual odometry algorithms to achieve a precise estimation of the system states. As it will be seen when the tasks the teams must complete are described, much of their potential success rests in finding innovative solutions to these problems to accommodate the proposed challenges and environmental and hardware restrictions.

Another challenge is finding a balance between flight stability and maneuverability, as time is used as a tie-breaker in most of the competition stages. Very stable drones might incur fewer mistakes but perform very slowly. This demands solving the control problem of the flight control loop in quadrotors. Several of the tasks also demand the inclusion of additional tasks to perform computer vision challenges and object interaction, which bring their own complexities to the design of the robots.

All code used in the challenges must be run by the computers embedded in the quadrotors. Thus, teams are also required to have auditable interfaces for their quadrotor flight systems. During the competition stages, generally, the only human interaction allowed is a mission start command, and the input of this command must be clear for the judges. Flight logs must be made available on request should any questions regarding the scoring be posed by either the judges or competition participants. These flight logs must contain both general positional data for the robot and task-specific entries attesting to the autonomous operation of the system.

IEEE UAS Association, Inc. - All Rights Reserved

III. THE COMPETITION ARENA

The arena of the 2023 FRTL can be seen in Fig. 3. The construction of this arena is based on the Gazebo model, shown in Fig. 4. It has a square shape with a side of 8m, and a minimal height of 4m, depending on the competition site conditions. A protective net is strung across all external surfaces to avoid accidents while still allowing the competition to be spectated. Strict safety practices are adopted, with all team members being required to wear individual protection equipment while inside the arena.
The original concept for the arena was to replicate operating conditions similar to those found in offshore oil rigs, an environment that poses several interesting challenges for the operation of aerial robots. The arena has a starting base, two elevated landing bases, and a set of shelves in fixed positions. During certain competition stages, additional landing bases might be placed on the ground. The fixed bases reflect fixed landing stations in oil platforms, while the ground landing bases with variable positions are meant to represent moving targets such as boats, other aerial vehicles, and rescue targets. The teams are informed of the intended base arena dimensions and fixed element positions, knowing that due to inevitable variations in the construction process, small deviations will be present. These small differences benefit the competition by replicating the variable conditions that robots find in the environment during their missions.

Figure 3
Competition arena in the 2023 FRTL.

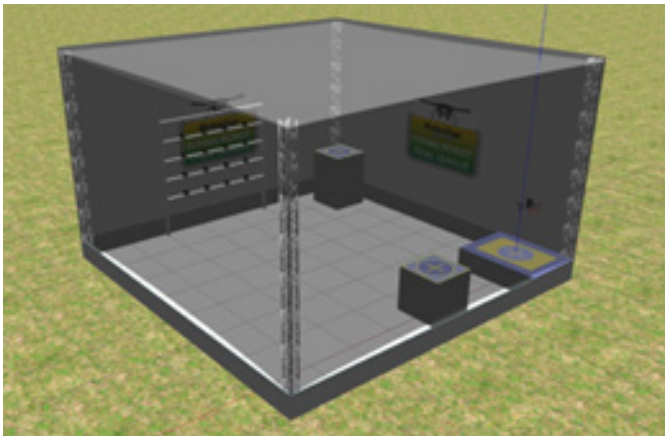


Figure 4
Gazebo model of the FRTL arena.

Before the proper competition stage, time is allocated for warm-up sessions for each team, to give them the opportunity to calibrate sensors in different lighting and environmental conditions, and to ensure that their UAVs are working to minimally accepted standards. However, they are not allowed to use any measuring devices to determine the actual arena dimensions.

IV. THE COMPETITION STAGES

The current FRTL is divided into four competition stages and a technical paper presentation. For each stage, the teams are allotted up to 30 minutes, where they may perform 3 attempts. The highest score will be taken from each stage, and the team with the highest total across all challenges is the winner. When designing the tasks, the competition chairs adhere to a series of guiding principles:

1. Each task must be directly related to current problems in the state-of-the-art for flying robots, such as identifying and collecting packages or performing multiple autonomous landings and take-offs in an unknown environment.
2. The tasks must adapt these problems into challenges that can be accommodated in the competition arena and are of feasible execution by teams of undergraduate-level students.
3. The tasks must increase in difficulty each year according to the overall team performance in the previous year's competition. Therefore, tasks where most or all of the teams were able to achieve expressive scores should either change drastically or be removed in favor of new ones. By contrast, tasks that showed themselves beyond the abilities of most teams should either remain unchanged or undergo minimal modifications.

IEEE UAS Association, Inc. - All Rights Reserved

These guidelines prevent winning teams from resting on their laurels by establishing very efficient pipelines for executing the same challenges every year, incentivizing true innovation, and allowing teams to tackle hard challenges multiple times. At the same time, checks and balances are introduced to avoid tasks beyond the current capabilities of the competitors and unnecessary changes, so that acquired technical skills can be used by the students to improve their results over the years. To illustrate this competition evolution process, the competition stages from the 2023 FRTL, conducted at the 2023 edition of the Brazilian Robotics Competition (CBR) in Salvador, Brazil, will be compared against the tasks proposed for the 2024 FRTL, which will happen at the 2024 CBR.

A. LOCATION AND MAPPING

The first stage of the 2023 FRTL was composed of the following steps:

- The competition chairs place the ground bases in random positions along the arena floor.
- The quadrotors must take-off from the landing base, recognize all five bases through computer vision (the two fixed ones and the three mobile ones).
- They must land in all of them in any order of their choosing.
- Each base counts for a given amount of points, with the mobile bases scoring higher.
- Should two or more teams manage to land in all bases the task execution time is used as a tie-break.
- Teams are penalized if their robot lands in the same base more than one time.

Therefore, this task demands that the teams solve both the vision problem related to locating the position of the ground bases, reflecting the challenges of navigating in an unknown environment, and the path planning problem of setting the most efficient route possible within the restrictions of their quadrotor.

In the 2023 edition of the competition, several teams struggled with this first task due to odometry failures that prevented them from landing on the bases. Teams that opted for LIDAR or RGB-D-based approaches found that the variations in the environment of the exposition center where the competition was held led to system failures, while teams using visual odometry faced calibration problems. As a result, scores were low in this stage. To allow teams another chance to solve this issue, for the 2024 FRTL, the competition organization decided to maintain essentially the same structure for this task, with the sole change being the addition of an extra ground landing base.

B. INVENTORY TRACKING

The second stage of the 2023 competition challenged the teams to correctly identify packages in a set of shelves, a common scenario in logistics operations performed in warehouses. For this purpose:

- A series of boxes containing barcodes were randomly placed on shelves, as shown in Fig. 5.
- The quadrotors needed to fly up to the shelf, correctly label each of the barcodes, and return to the landing base.
- Each correct reading was worth a given amount of points, with incorrect readings deducted from the total score.
- The teams were required to prove that the correct label was assigned to a given package should the visual system used by any of the teams capture more than one barcode at the same time.
- To increase difficulty, the robots should cover the whole shelf during flight. That is, they cannot read all barcodes from a single image.

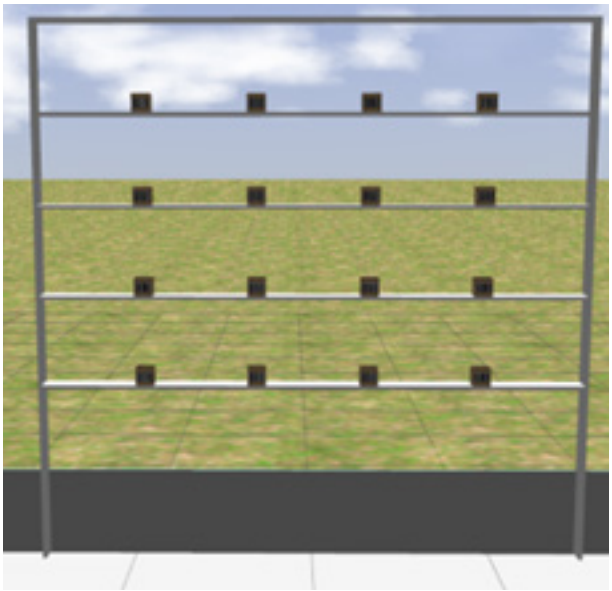


Figure 5
Shelves with barcode packages placed in the Gazebo simulator.

To better illustrate the task execution, a video of an attempt is available at this link:
https://www.youtube.com watch?v=aqdPf_21NGQ

IEEE UAS Association, Inc. - All Rights Reserved

This was the second most successful stage regarding team scoring during the competition. Several teams using both off-the-shelf and custom quadrotors were able to fly close to the shelf accurately and scan the barcodes correctly. It should be noted that although reading barcodes is already a well-known problem, doing so from video captured from a flying quadrotor under less-than-ideal light conditions demands that teams apply several image processing algorithms to compensate for distortions due to movement and vibration. The goal is to arrive at a segmented image that can then be used as input for barcode reading algorithms.

This challenge precipitated a change in the league regulations, as several teams had less-than-ideal flight logs to prove that their barcode readings were accurate. This led to clearer and stricter guidelines in the 2024 rules. The overall structure of the stage was kept for the 2024 FRTL, but now, barcodes can be placed either horizontally or vertically. Also, two barcodes can be placed with no horizontal gap between them. This significantly increases the image processing problem that the teams must face, which demands both correctly segmenting the image to isolate barcodes and ensuring sufficient quality so that the barcodes can actually be read.

C. PARCEL TRANSPORT

For the third stage of the 2023 FRTL, the teams must transfer parcels to designated targets in the arena:

- The landing bases are placed in fixed positions and tagged with a letter code. The teams are informed of these positions and of the letter codes beforehand.
- Parcels consisting of a styrofoam block with a metal plate and a printed QR-code are randomly distributed, as shown in Fig. 6. The QR-code in each parcel corresponds to one of the bases in the arena.
- The quadrotors must correctly identify and transport each of the parcels to the correct destination.
- Teams receive points for correctly identifying the parcels and delivering them to the appropriate location. They are penalized for misidentifying the QR-codes, dropping packages mid-transport and delivering them to the wrong destination.
- Partial points are awarded if a robot manages to read a QR-code and move to the appropriate base, without moving the package.

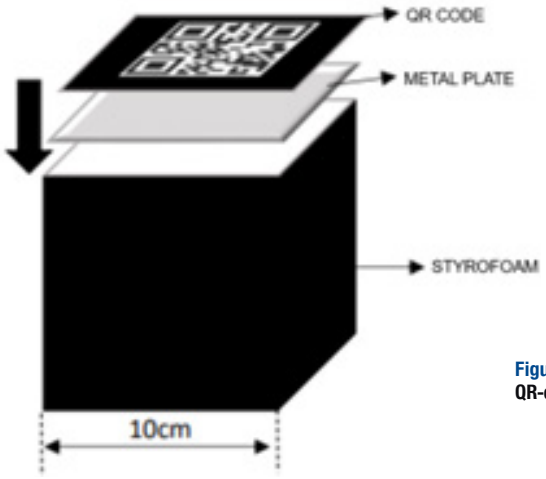


Figure 6
QR-code labeled package.

This task brings additional complexity to the competition, as a solution for grabbing the parcels from the ground must be developed, such as a claw or electromagnet for the metal plate in the packages. Not only must this solution be strong enough actually to grab the parcel, but the UAV must also compensate for the additional weight and be precise enough to align whatever grabbing mechanism it has with the package itself.

This added complexity made this the hardest stage for most teams in the 2023 competition. While several of them were able to identify the packages, earning a few points correctly, none of the proposed solutions for the actual parcel transport were successful. The localization and vision problems of the previous stage were compounded by the mechanical problem, and the teams were only able to obtain a part of the full score by moving to the proper base after correctly reading the QR-code in the parcels. Therefore, in the 2024 edition of the league, this task remains unchanged in the hopes that teams were able to refine their approaches in the last year.

IEEE UAS Association, Inc. - All Rights Reserved

D. LANDING ON A MOVING TARGET

The final challenge of the 2023 FRTL was the following scenario:

- A ground robot was set to perform a lemniscate trajectory on the arena floor.
- A landing base was placed at the top of the robot, and the teams needed to program their robots to land on this base, then take off and return to the starting point.
- Teams were awarded points for landing on the base atop the robot and additional points for returning to the starting location.
- The robot speed and trajectory dimensions were communicated to the teams beforehand.

Relating to real-life scenarios, this should have been one of the hardest challenges of the competition, if not the hardest. Identifying a moving landing base is already a considerable challenge given the restricted resources of a quadrotor, much less performing a landing maneuver on it, considering the maneuverability restrictions of the indoor competition environment. It came as a surprise then that this was the easiest task for the teams in the 2023 FRTL, and it taught an important lesson to the league organization regarding task design.

Due to technical problems with the ground robot, the actual speed of the moving target could have been faster. Coupled with the restricted arena size, this made the robot trajectory very predictable, enabling most teams to execute brute-force strategies to almost guarantee a landing between their three attempts. This was far from the goal of the competition, but in the absence of rules specifying that teams were obliged to prove that they were tracking the moving target, the only fair option was to judge them according to the established league regulations. Moreover, the ground robot proved itself challenging to operate due to the need for identical conditions during the attempts of each team. This led to several delays in the competition.

The first change derived from this experience was a thorough rewrite of the 2024 FRTL rules to eliminate ambiguities and avoid loopholes such as the one that happened in this case. The second was that due to the overall high scores from all teams and the unreliability of the ground robot-dependent setup, a new task would be formulated for the next edition:

- This new task involves the interaction of a formation of two quadrotors with a human inside the arena.
- A set of simple tasks are set for the formation, such as landing, taking-off or moving in a given direction, but they must be executed only if a corresponding gesture made by the human is recognized.
- All mobile bases are placed in the arena, and the quadrotor must land in all of them when commanded so by the human in the arena
- Teams are scored for each correct landing and penalized for repeat visits.

As a concession to the security of the person inside the arena the maximum allowed size and weight for the quadrotors in this new task were reduced when compared to the other stages of the competition. This new setup demands many of the same skills required of the previous task, such as recognizing a moving target and performing dynamic movements, but is significantly less complex in terms of implementation for the league organization and leaves less margin for teams circumventing the posed requirements.

E. TECHNICAL SESSION

Although the FRTL challenges aim to cover a broad spectrum of skills regarding the construction and operation of aerial robots, it is evident that not all aspects of the solutions designed and implemented by the participating teams will be visible during the execution of the tasks. Several of the most important innovations that each of them brings to the table might be hidden in a clever implementation of an attitude controller or in a unique electronic project that boosts their robot's energy efficiency. To contemplate these aspects of their efforts, each team is required to submit a technical description paper when signing up for the competition:

- This paper must describe in detail how they solved each of the main challenges for a quadrotor robot.
- These technical papers are presented in a technical session to a panel of judges with appropriate academic backgrounds.
- The teams are guided to explain what algorithms and solutions they employed in their robots, with the judging guidelines rewarding the teams that present the most innovative approaches.
- To reward the best and most innovative paper, a separate prize is given, distinct from the one for the team that performed better in the actual competition.

The most important benefit of these technical sessions is that the other participating teams get insights into the solutions developed by their competitors, therefore increasing the overall competition level each year, and fostering the natural collaborative nature of the scientific endeavor.

IEEE UAS Association, Inc. - All Rights Reserved

V. THE RESULTS SO FAR

The FRTL was established in 2018, beginning with a flight demonstration at the Brazil Robocup, to garner interest in teams participating in other categories to join the competition in the coming year. Already in the following year, several teams participated, resulting in the first championships. Although the goal of the league is to foster advancements in the state-of-the-art, the first years of any robotics competition are guided by an effort to encourage regular participants who will motivate one another through competition and solidify regulations and procedures. By this metric, these early stages were a success. However, the COVID-19 pandemic threw a wrench in the league's plans for further expansion in 2020. With the restrictions of large gatherings due to health concerns, the competition was moved to an online environment in 2020 and 2021, with the teams competing in challenges using the Gazebo simulated environment. While the teams performed admirably in these remote editions of the FRTL, this focus on simulation meant that the teams' solutions to the competition problems were not tested in real robots. Most robotics journals and conferences shifted their judging criteria for accepting works in recent years to demand that any proposed algorithms and new techniques be tested in real-robot environments to set higher standards for new contributions, and the FRTL wishes to reflect these stricter requirements in the competition. Therefore, the intended fruits of the FRTL were delayed.

As the gathering restrictions were lifted with the end of the pandemic, in-loco competitions were resumed in 2022. While some of the progress made in the early years was lost, the league was quick on the uptake, with several teams already participating for several years at this point. These efforts culminated in the 2023 edition of the FRTL, which saw the highest proposed task complexity and number of participating teams. Derived from the efforts of the teams to innovate, works were published using the teams' innovations for the competition as their test cases, dealing with subjects such as efficient route planning[11], system verification for robotics systems [12], and system design[13]. These are all works from researchers associated with the FRTL competing teams and only those directly associated with the competition. The overall amount of work that indirectly results from the competition's efforts is probably much higher. All of these research groups use the expertise acquired in the competition to power their efforts in other research problems that might not be within the scope of the competition.

These results show that the FRTL is achieving its goal of fostering innovation through competition and that since its establishment, the league has seen an upward trend. The 2024 edition is shaping up to be the most competitive so far, with several teams that had strong showings in previous years participating again. The complete rules for this edition of the competition are available at[14]. In the following years, the hope is that the league can continue to expand, with the ultimate goal being its internationalization and integration with other aerial competitions around the world.

ACKNOWLEDGEMENTS

The authors would like to thank RoboCup Brazil for providing the environment for this competition to flourish.

REFERENCES

[1] P. Stone, «Designing Robots to Best World Cup Winners Has Inspired Generations of Roboticists,» in IEEE Spectrum, vol. 60, no. 7, pp. 40-49, July 2023, doi: 10.1109/MSPEC.2023.10177053.

[2] A. Deleforge, D. Di Carlo, M. Strauss, R. Serizel and L. Marcenaro, «Audio-Based Search and Rescue With a Drone: Highlights From the IEEE Signal Processing Cup 2019 Student Competition [SP Competitions],» *in IEEE Signal Processing Magazine*, vol. 36, no. 5, pp. 138-144, Sept. 2019, doi: 10.1109/MSP.2019.2924687.

[3] D. Gallarta-Sáenz, J. Rico-Azagra and M. Gil-Martínez, «Learning Enhancement of Control Engineering: A Competition-Based Case,» *in IEEE Access*, vol. 11, pp. 38240-38250, 2023, doi: 10.1109/ACCESS.2023.3267966.

[4] S. Evripidou, K. Georgiou, L. Doitsidis, A. A. Amanatiadis, Z. Zinonos and S. A. Chatzichristofis, «Educational Robotics: Platforms, Competitions and Expected Learning Outcomes,» in IEEE Access, vol. 8, pp. 219534-219562, 2020, doi: 10.1109/ACCESS.2020.3042555.

[5] E. Antonioni, V. Suriani, F. Riccio and D. Nardi, «Game Strategies for Physical Robot Soccer Players: A Survey,» in I*EEE Transactions on Games*, vol. 13, no. 4, pp. 342-357, Dec. 2021, doi: 10.1109/TG.2021.3075065.

[6] M. N. Boukoberine, Z. Zhou, M. Benbouzid, "A critical review on unmanned aerial vehicles power supply and energy management: Solutions, strategies, and prospects", in *Applied Energy*, vol. 255, Dec. 2019, https://doi.org/10.1016/j.apenergy.2019.113823.

[7] K. Ebadi et al., «Present and Future of SLAM in Extreme Environments: The DARPA SubT Challenge,» in IEEE Transactions on Robotics, vol. 40, pp. 936-959, 2024, doi: 10.1109/TRO.2023.3323938.

[8] J. Lima et al., «An Industry 4.0 Approach for the Robot@Factory Lite Competition,» *2020 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC)*, Ponta Delgada, Portugal, 2020, pp. 239-244, doi: 10.1109/ICARSC49921.2020.9096164.

[9] D. Erdos, A. Erdos, and S. E. Watkins, «An experimental UAV system for search and rescue challenge,» in *IEEE Aerospace and Electronic Systems Magazine*, vol. 28, no. 5, pp. 32-37, May 2013, doi: 10.1109/MAES.2013.6516147.

[10] L. A. Fagundes-Junior, C. O. Barcelos, D. C. Gandolfo and A. S. Brandão, «BDP-UaiFly System: A Platform for the RoboCup Brazil Open Flying Robot Trial League,» *2023 International Conference on Unmanned Aircraft Systems (ICUAS)*, Warsaw, Poland, 2023, pp. 1021-1028, doi: 10.1109/ICUAS57906.2023.10156168.

[11] A. Sales et al., «Vision-based K-Nearest Neighbor Approach for Multiple Search and Landing with Energy Constraints,» 2023 Latin American Robotics Symposium (LARS), *2023 Brazilian Symposium on Robotics (SBR), and 2023 Workshop on Robotics in Education (WRE)*, Salvador, Brazil, 2023, pp.71-76, doi: 10.1109/LARS/SBR/WRE59448.2023.10333019.

[12] M. Santos, M. C. Filho and A. Sampaio, «A Model-based Approach to the Development and Verification of Robotic Systems for Competitions,» *2023 Latin American Robotics Symposium (LARS)*, Salvador, Brazil, 2023, pp. 236-241, doi: 10.1109/LARS/SBR/WRE59448.2023.10333030.

[13] Laboratory for Robotics and Intelligent Control Systems, University of Zagreb (2024) "*ICUAS '24 UAV Competition Rulebook*". [Online]. Available: **https://tinyurl.com/3n9ds6un.**

[14] RoboCup Flying Robots League, Brazilian Robotics Competition (2024). "*RoboCup Brasil Flying Robot Trial League*". [Online]. Available: **https://tinyurl.com/4chsuewe**

ICUAS Association, Inc. - All Rights Reserved

FROM SKY-HIGH DREAMS TO GROUNDED REALITY? REGULATORY CONSIDERATIONS BEHIND AIR-TAXIS IN PARIS OLYMPICS

ÖYKÜ KURTPINAR, LEIDEN UNIVERSITY INTERNATIONAL INSTITUTE OF AIR AND SPACE LAW

CREDIT FOTO: © Volocopter GmbH

The whispers of flying taxis filled the air in anticipation of the 2024 Paris Olympics. However, the dream of flying through the City of Lights in an electric vertical takeoff and landing (eVTOL) vehicle seems to have hit turbulence. The reasons underlying such downgrading of expectations seem to be debated: Was this a case of overblown expectations, regulatory roadblocks, or simply, Parisian scepticism?

What are flying taxis and what is the Hype?

From Blade Runner to the Jetsons, air taxis feel like pieces of creativity from science fiction movies. However, the aviation industry now stands at the threshold of an innovative air mobility landscape embodying various cutting-edge technologies. EVTOLs for passenger mobility, marketed as air taxis, promise to revolutionise urban and rural transportation. With over 100 vehicle designs and prototypes, eVTOL companies envision a green and potentially autonomous future of commuting. Yet, the audience remains divided. Enthusiasts eagerly await their arrival, while sceptics fear they'll follow the path of on-demand helicopters – a novelty that failed to take off.

IEUAS Association, Inc. - All Rights Reserved

A new deadline, Paris Olympics, but the Parisians Say 'Non':

Volocopter, a major player, announced plans to offer air taxi services for the 2024 Paris Olympics. What was the initial idea? EVTOLs, whisking sports fans between five popular hubs in Paris such as airports to other airports, or to train stations. Collaboration with the French Government was underway, with the construction of five vertiports around the city already in progress. Yet, the eVTOL companies have a history of missed deadlines.

The scepticism is palpable, with Parisian authorities and activists voicing concerns about noise, safety, affordability, and elitism. In November 2023, the councillors of Paris unanimously dismissed the project, with the Deputy Mayor defining air taxis as "A totally useless and hyper-polluting gadget for a few ultra-privileged people in a hurry". The reactions were not limited to the elected governors of the city. Extinction Rebellion activists 'redecorated' the offices of the General Directorate of Civil Aviation (DGAC) with spray paints, protesting against the project, calling it "as stupid as it is useless".

The CEO, Hoke, has previously stated that the idea of air taxis in the Paris Olympics came from Emmanuel Macron "to demonstrate innovation in France in the summer of 2024," and allegedly invited the French President to be the first passenger. Therefore, the Paris Olympics air taxi project highlights also the complex interplay between governmental interests, local concerns, and the broader regulatory landscape surrounding eVTOLs.

The Regulatory Labyrinth: Balancing Innovation and Safety in the Evolving eVTOL Landscape

Industry participants hold divergent views on the regulatory landscape. Some cite regulatory hurdles in the EU as the primary obstacle to achieving scaled operations, pointing at the faster processes in countries such as China, Saudi Arabia and Japan. On the other side, some criticise the lack of sufficient regulations for operations.

As witnessed first-hand at Amsterdam Drone Week, the European Union Aviation Safety Agency (EASA) occasionally faces the criticism over lack of sufficient regulations. During the conference, an EASA representative expressed her readiness to develop additional rules if it is really necessary. The EU has demonstrably exhibited a proactive stance on eVTOL and drone regulations. They have enacted a series of regulations specifically targeting UAS operations, and U-space and established various guidance materials, certification requirements, and special conditions for small and passenger VTOLs. This level of comprehensiveness surpasses many other global counterparts. Nonetheless, the representative drew attention to the obvious lack of scaled operations in the current industry, despite EASA's significant efforts to create comprehensive regulations. On the other hand, the slow uptake in operationalising these regulations raises questions about their effectiveness and the industry's current readiness for scaled implementation.

The Precautionary Principle vs. The Need for Real-World Data

This regulatory tug-of-war reflects a long-debated but fundamental question: should regulations precede implementation, or should real-world experience inform regulatory frameworks? Did the EU move too quickly by imposing safety regulations without the benefit of observing real-world applications and before the eVTOL industry had a chance to fully mature? Or was this proactive approach necessary to ensure a safe launch and maintain public confidence?

EASA's safety-first approach reflects traditional civil aviation practices. They prioritise clear safety rules to prevent accidents and protect everyone before eVTOLs fill the skies. Why? One bad crash could have disastrous consequences and erode public trust entirely. Clear safety and security regulations can actually help build that trust. Plus, EU-wide regulations mean companies can operate across borders without the headache of complying with different national laws.

There's a flip side. Overly cautious regulations might clip innovation's wings. Amsterdam Drone Week conversations buzzed with industry stakeholders stressing the need for real-world data to improve operations. Moreover, certification and compliance with regulations can be expensive and time-consuming to comply with,

IEEE UAS Association, Inc. - All Rights Reserved

especially for start-ups. This could stifle competition and slow down the entire industry's progress. Many eVTOL companies are already navigating serious financial difficulties, struggling to secure necessary investments. Their primary focus remains to be surviving until they achieve the crucial milestone of certification.

Air Show or No Show? The Uncertain Future of Flying Taxis

Volocopter is required to gain different certifications and even the CEO of the company Hoke has stated "To be honest, I can't guarantee that we'll be flying certified operations during the Olympics." Certain exemptions are already afforded to the project, circumventing certain formal procedures that scaled commercial operations would have to go through. On July 4th 2024, France's official gazette, the Journal officiel de la République française, published an ordinance authorizing flying taxis during the Paris 2024 Olympic Games and until the end of this year, although with specific limitations. Volocity is permitted to fly between 8 am and 5 pm, with a maximum of two flights per hour. Following the ordinance allowing for flying taxi operations, the buzz around flying taxis is palpable, but so are the financial constraints faced by key players like Volocopter. Adding to the complexity, **La Monde** has reported two urgent applications for interim injunctions seeking the cancellation of the ordinance.

More interestingly, despite these developments, silence regarding the air taxi demonstrations persists, as there appears to be no concrete news or promotions of actual air taxi operations taking flight. Recent updates suggest a potential shift towards an 'air show' concept for the Olympics, where air taxi services might be demonstrated for 'guests' rather than paying passengers. This scenario would serve as the initial 'test' for air taxis in Europe, allowing local authorities to conduct a cost-benefit analysis and observe the public acceptance and short-term environmental impacts. Regardless, regulatory ambiguities persist. Such operations, likely conducted under special exemptions, would involve point A to point A mobility, potentially falling outside the EU's traditional 'transportation' competencies. As legal professionals, our hopes for a comprehensive real-world test of commercial-certified category UAS regulations may have been deferred.

While eVTOLs represent a glimpse into a futuristic transportation landscape, the Paris case study exposes the complex challenges they face. There are other high-profile promises on the horizon, like the Winter Olympics in Milano. So, while one missed target is not necessarily a big issue, it could lead to more missed targets in the future, potentially stalling progress in this exciting sector. Overcoming regulatory hurdles, gaining public trust, and establishing a viable business model that brings value to communities are crucial steps before these flying taxis can take off on a grand scale.

REFERENCES

'City of Paris Takes Legal Action against "flying Taxis" during Olympic Games' Le Monde.fr (19 July 2024) <**https://www.lemonde.fr/en/environment/article/2024/07/19/city-of-paris-takes-legal-action-against-flying-taxis-during-olympic-games_6690309_114.html**> accessed 29 July 2024

'Volocopter Chief Wants Macron to Be Paris' First Passenger before 2024 Olympics' (1687528999) <**https://www.insidethegames.biz/articles/1138228/macron-paris-2024-flying-taxi**> accessed 29 July 2024

designboom matthew burgos |, 'France Authorizes Flying Taxis to Take Flight in Paris during 2024 Olympic Games' (designboom | architecture & design magazine, 10 July 2024) <**https://www.designboom.com/technology/france-flying-taxis-paris-2024-olympic-games-volocopter-volocity-07-10-2024/**> accessed 29 July 2024

Journal officiel de la République française, 'Order of July 4, 2024 Establishing the Paris-Austerlitz Vertiport and Opening It to Public Air Traffic'

Lecca T, 'Why You Won't Fly in an Air Taxi at the Paris Olympics' (POLITICO, 14 February 2024) <**https://www.politico.eu/article/why-you-wont-fly-air-taxi-paris-olympics/**> accessed 29 July 2024

I&UAS Association, Inc. - All Rights Reserved